Virtual Guidance for Medical Ultrasound Procedures on Exploration Class Missions

David S. Martin,
Wyle Integrated Science and Engineering Group
Timothy L. Caine,
Wyle Integrated Science and Engineering Group
Timothy Matz, *MEI Technologies*
Michael B. Stenger,
Wyle Integrated Science and Engineering Group
Steven H. Platts, *Johnson Space Center*

Ultrasound can be used to image nearly every part of the body, making it a useful, noninvasive tool for both research and diagnostic studies. Hardware advances have resulted in compact designs, making ultrasound an ideal imaging modality for use on the International Space Station (ISS) and future manned space vehicles. The size and up-mass requirements of other medical imaging equipment make their deployment in space vehicles problematic. However, ultrasound imaging is traditionally a highly operator-dependent modality, and requires lengthy training to perfect. To obtain quality ultrasound images on the ISS, much of the expertise has been shifted to the ground in the form of remote guidance. This technique involves minimal astronaut training coupled with real-time remote guidance from an expert on the ground. The technique has been used successfully with several research projects requiring ultrasound on the ISS and has been validated in diagnostic clinical scenarios, as well. With plans for missions of greater duration and distance from Earth, the time delay in communication from Earth to a spacecraft can increase substantially, projected to be as long as 40 minutes on a Mars mission. In this setting, remote guidance will not be a realistic possibility, and astronauts will be forced to operate more autonomously ("just in time training"). Virtual Guidance ultrasound is designed to fill this gap. Virtual Guidance is a comprehensive audio/video tutorial designed to guide an untrained operator through a detailed ultrasound study without the need for extensive training or remote guidance. The purpose of this study was to demonstrate the feasibility (on the ground) of Virtual Guidance to obtain clinically relevant measures of the carotid artery including intima-media thickness.

Methods

In a step-by-step manner, the Virtual Guidance tutorial demonstrates equipment setup, patient/subject positioning, ergonomics of scanning, study protocol, location and when to use controls, as well as scanning guidance. Intended operators are likely to initially produce less than adequate images; therefore, a series of typical scanning errors are demonstrated along with strategies to recover. This tutorial is viewed in real time using commercially available virtual reality video glasses, while the operator performs the ultrasound scan. The video glasses allow hands-free, full screen viewing of the tutorial while maintaining an unobstructed view below the glasses of the ultrasound screen, keyboard, and patient. The audio/video tutorial program can reside on any video source including—but not limited to—iPod, laptop computers, and DVD players. For the current study, the tutorial was stored on, and played back through, an Apple iPod.

Researchers recruited 10 untrained subjects to operate an ultrasound system, acquiring images and Doppler from a carotid artery of a subject using only Virtual Guidance for instruction. Commercially available ultrasound equipment was used (Philips CX50, Philips Medical, Andover, Mass.). Images selected by the scanner, with advice from only the Virtual Guidance tutorial, were stored digitally. Additionally, two trained sonographers scanned the same subject for comparison purposes.

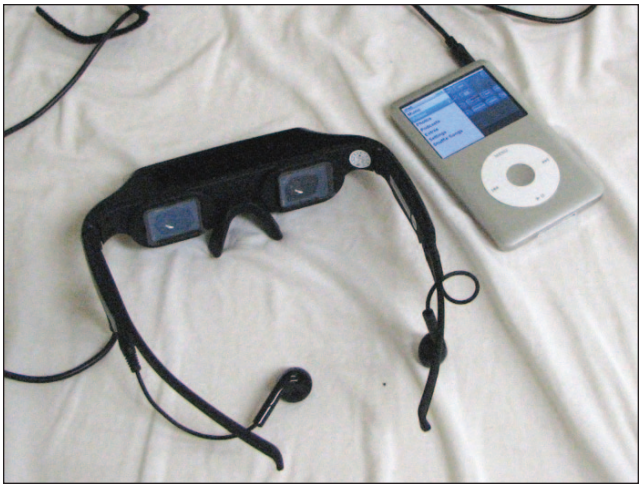

Fig. 1. *Video glasses and iPod.*

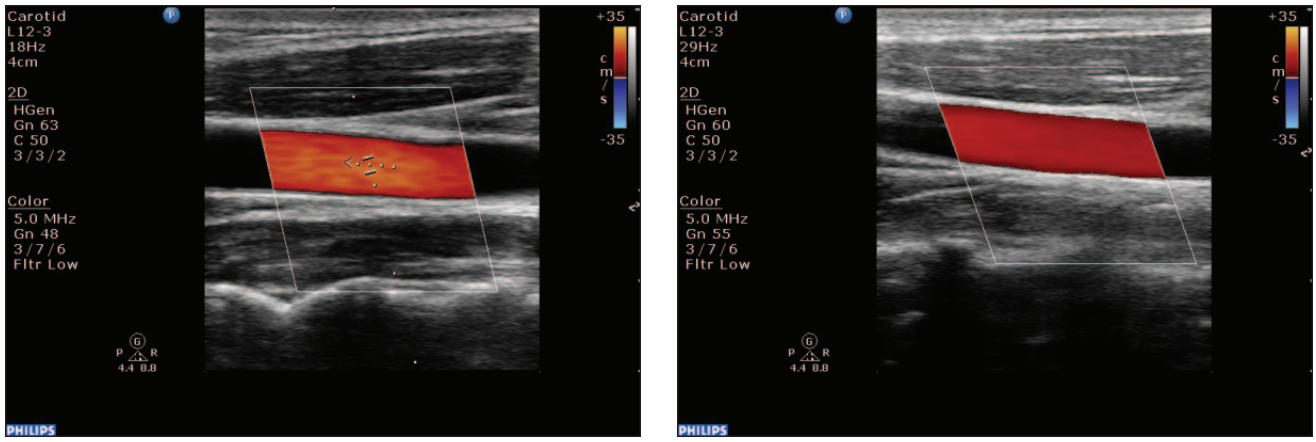

Fig. 2. *Color Doppler of the carotid artery from: a) an untrained scanner; and b) an experienced sonographer.*

Results

A cardiologist who was experienced in interpreting cardiovascular ultrasound images evaluated and scored the images. Eight of the 10 untrained operators achieved scores that were considered to be diagnostically adequate.

Conclusions

This study demonstrated the ability of untrained operators to acquire diagnostically adequate images of a carotid artery with guidance from only Virtual Guidance. The untrained operators in this study were at somewhat of a disadvantage when compared to crew members on ISS, who typically have introductory ultrasound training preflight when participating in a research study that involves remote guidance ultrasound. Additionally, greater success would be anticipated if time and budget allowed for further refinement of the tutorial video. While this tutorial was specifically developed for carotid artery, it is possible that tutorials could be developed for any of the many terrestrial clinical or research ultrasound applications.